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(71) Applicant

The General Electric

Company plc

(Great Britain),

1 Stanhope Gate, London

W1A 1EH

(72) Inventors

Dennis Laurence Lewis,

Tin Ming Ong,

Bruce Elphinston

Robertson,

Anthony John Walkden

(74) Agent and/or Address for  
Service

M. B. W. Pope,

Central Patent

Department (Wembley

Office), The General

Electric Company plc,

Hirst Research Centre,

Wembley, Middlesex

HA9 7PP

(54) Tactile sensor

(57) In a tactile sensor of the kind comprising a compressible mat (1) of electrically resistive material and an array of electrodes (3, 5) on at least one main face of the mat the electrically resistive material comprises filaments coated with electrically conductive material. Information regarding the shape, position, pressure exerted by an object can be obtained by scanning the resistance between pairs of electrodes. The filaments may be fibres of a natural or synthetic material. The sensed output may be fed to a microprocessor.

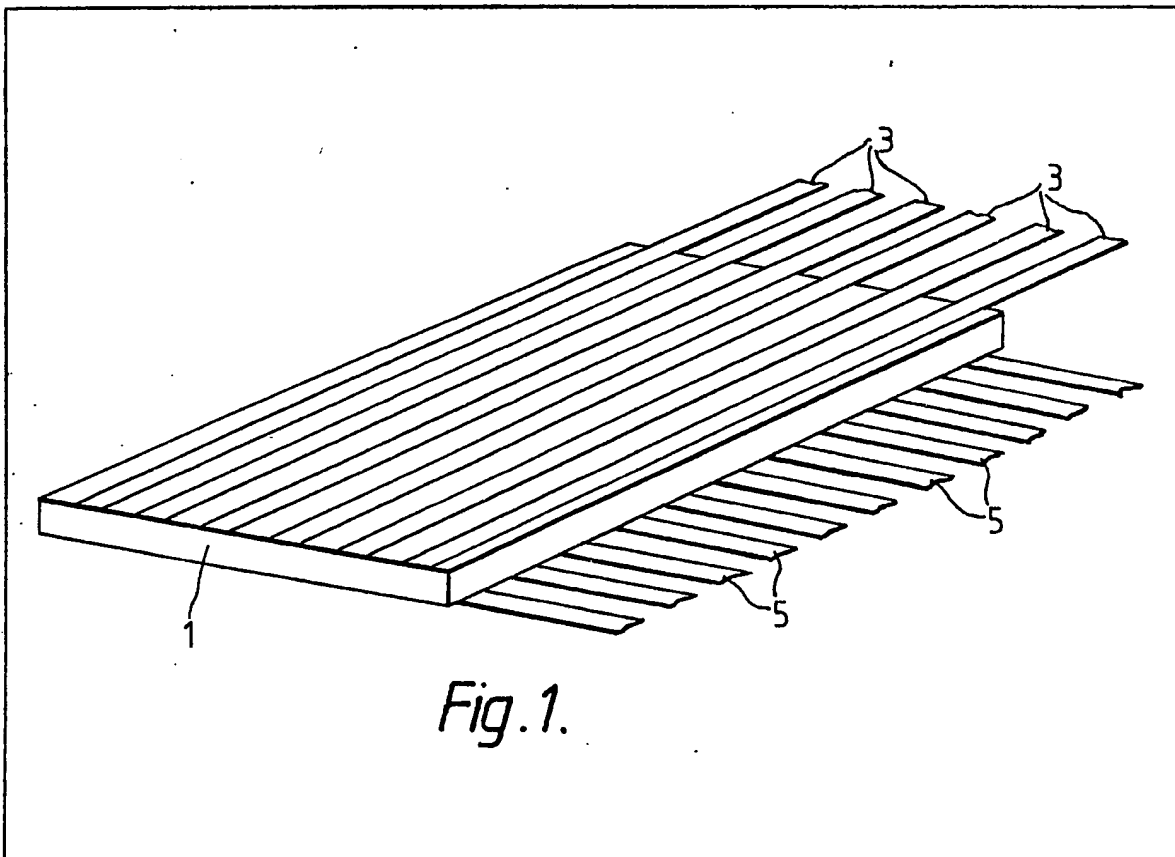


Fig. 1.

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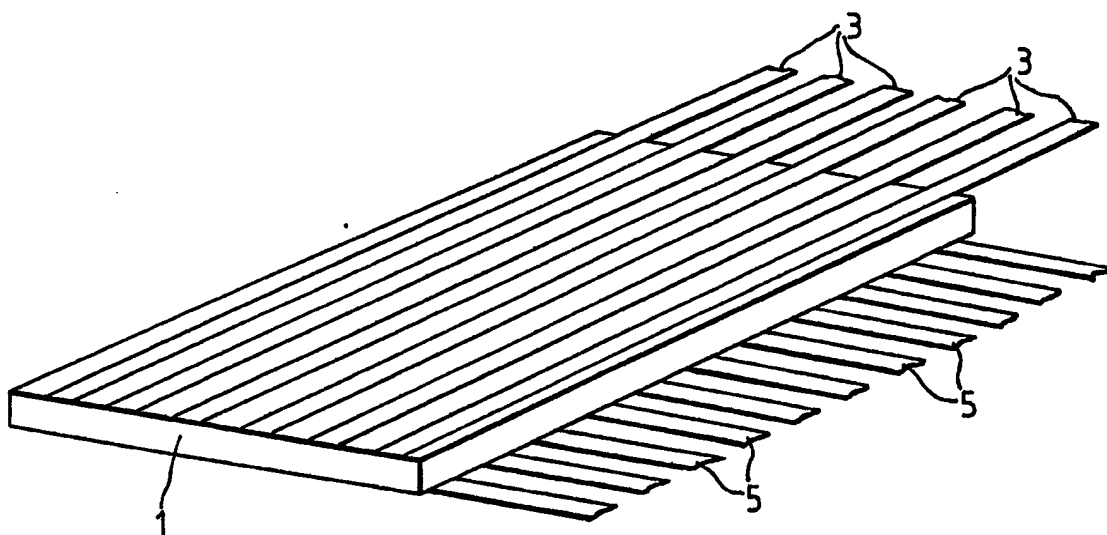


Fig. 1.

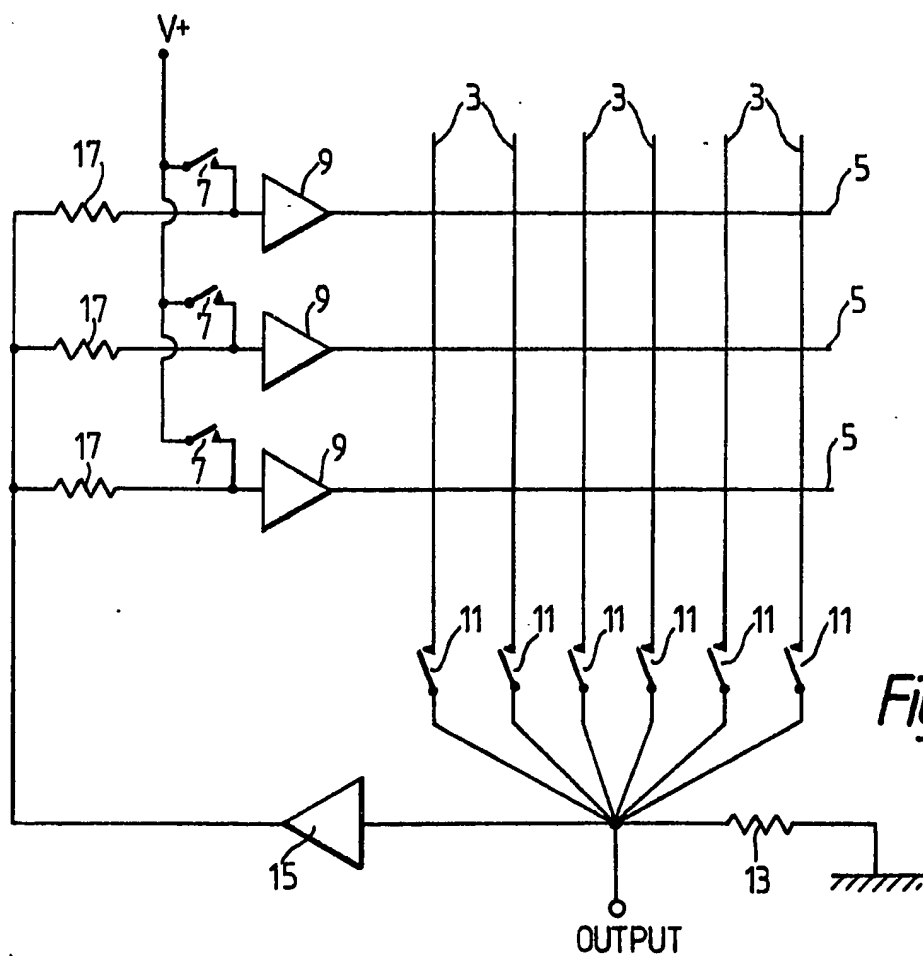
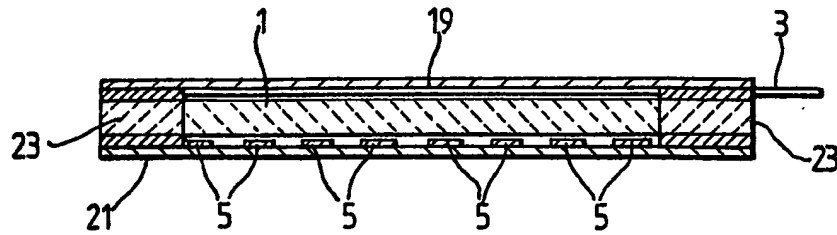
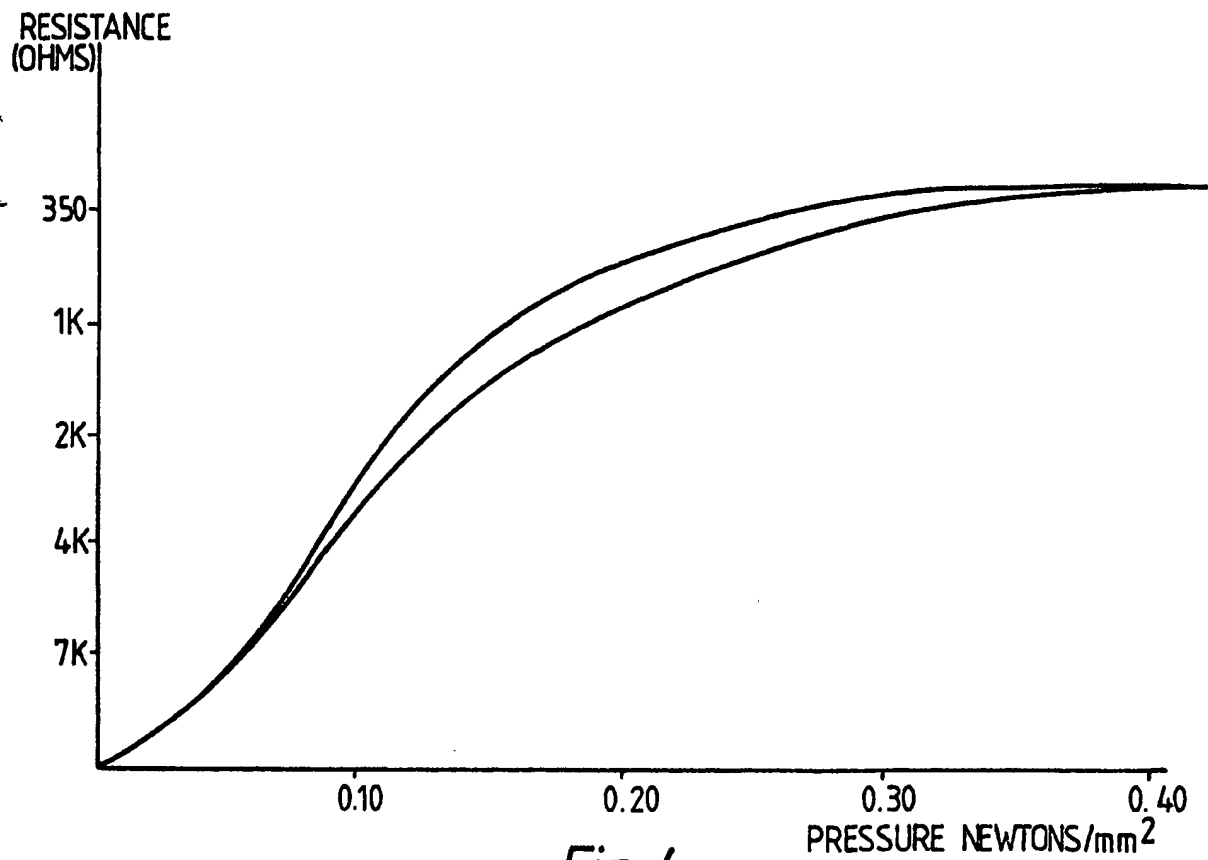


Fig. 2.

*Fig. 3.**Fig. 4.*

## SPECIFICATION

## Tactile sensors

This invention relates to tactile sensors.

More particularly the invention relates to tactile  
5 sensors of the kind (hereinafter referred to as the  
kind specified) comprising a compressible mat of  
electrically resistive material and an array of  
electrodes on at least one main face of the mat.  
Typically there is an electrode array on each main  
10 face of the mat, each array comprising a series of  
parallel spaced apart conductors with the  
conductors of one array extending transversely to  
the conductors of the other array.

In use of such a sensor information regarding  
15 the shape and position of an object contacting the  
sensor and the pressure exerted by the object can  
be obtained by scanning the resistance between  
pairs of the electrodes.

Known forms of tactile sensor of the kind  
20 specified suffer from a number of disadvantages,  
in particular that the variation of resistance with  
pressure exhibits hysteresis, and in the case of  
mats made of plastics materials, that resistance  
varies with the time that pressure is applied.

25 It is an object of the present invention to  
provide a tactile sensor of the kind specified  
wherein these disadvantages are alleviated.

According to the present invention in a tactile  
sensor of the kind specified the electrically  
30 resistive material comprises filaments coated with  
electrically conductive material.

The filaments are suitably fibres of a natural  
material, for example, wool fibres or a mixture of  
wool fibres and fibres of at least one other  
35 material such as cotton, in which case the  
electrically conductive coating material suitably  
comprises carbon particles.

Alternatively, the filaments may be fibres of a  
synthetic material, for example, aromatic  
40 polyamide fibres, in which case the electrically  
conductive material suitably comprises a graphite  
loaded polymer material.

The filaments may be bonded together with an  
adhesive.

45 The mat is suitably in the form of a cloth woven  
from yarn formed of filaments.

One tactile sensor in accordance with the  
invention will now be described by way of  
example with reference to the accompanying  
50 drawings in which:—

Figure 1 is a perspective view of the sensor;

Figure 2 is a circuit diagram of a scanning  
circuit for use with the sensor;

Figure 3 is a sectional view of the sensor of  
55 Figure 1 housed in a protective casing; and

Figure 4 is a graph illustrating the performance  
of the sensor.

Referring to Figure 1, the sensor comprises a  
mat 1 made of filaments coated with an  
60 electrically conductive material.

On each main face of the array there is provided  
an array of electrodes in the form of parallel  
spaced strips 3 or 5, the strips 3 on one main face  
extending at right angles to the strips 5 on the

65 other main face.

In use the sensor is connected with a scanning  
circuit arrangement, one suitable scanning circuit  
being shown in Figure 2.

The circuit comprises a voltage source V whose  
70 negative terminal is connected to ground and  
whose positive terminal is connected via  
respective switches 7 and amplifiers 9 to each of  
the electrodes 5 on one main face of the mat. The  
electrodes 3 on the other main face of the mat are  
75 connected via respective switches 11 to one end  
of a reference resistor 13 whose other end is  
grounded. The ungrounded end of the resistor 13  
is also connected to the input of a further amplifier  
15 whose output is connected via respective  
80 resistors 17 to the inputs of the amplifiers 9.

In operation of the arrangement each of the  
switches 7 is closed in turn and whilst each switch  
7 is closed, each of the switches 11 is closed in  
turn. The voltage across the resistance 13 is thus,  
85 in turn, representative of the resistance of the mat  
1 at each of the locations on the mat 1 where an  
electrode 3 crosses an electrode 5.

The voltage across the resistance 13, which  
constitutes the output of the sensor, thus provides  
90 significant information regarding the shape,  
position and pressure exerted by an object placed  
on the sensor mat. The sensor output is suitably  
fed to a micro-processor (not shown) for storage,  
processing and display in any desired manner. It  
95 will be appreciated that the switches 7 and 11,  
which will normally be of the solid state type, will  
also be operated under the control of the  
microprocessor.

In one particular form of the sensor described  
100 above with reference to Figure 1 the mat  
comprises a piece of cloth woven from yarn  
consisting of cotton and wool fibres coated with  
carbon particles in the form of carbon black.

The carbon black is suitably applied by soaking  
105 the cloth in a suitable grease solvent loaded with  
carbon black or by spraying the carbon black onto  
the cloth. If desired, the fibres may be bonded  
together with an adhesive, for example, a  
synthetic rubber-resin adhesive. The adhesive is  
110 suitably applied by soaking the cloth in the  
adhesive. Application of the adhesive and  
carbon black may take place simultaneously, or  
successively, in either sequence, although care  
may need to be taken to ensure good electric  
115 contact between the mat and electrodes in some  
cases.

To facilitate its use, the sensor of Figure 1 is  
preferably housed in a protective casing.

In one such arrangement, illustrated in Figure 3,  
120 the spaced strips 3 or 5 forming each electrode  
array are supported on a protective backing sheet  
19 or 21, for example of thin plastics material,  
lying on the side of the strips remote from the mat  
1. The backings 19 and 21 project beyond the  
edges of the mat 1 with the space between the  
projecting parts of the backings filled with a  
suitable material, such as strips 23 of the same  
cloth as the mat is made from, and with the  
backings 19 and 21 bonded to the strips 23 or

other filling material.

The electrode array strips 3 and 5 suitably consist of metal foil or silicone rubber loaded with metal, e.g. copper or silver. Alternatively, the electrode array may be formed by removing the insulation from end portions of the conductors of a multi-way cable and laying the stripped conductors out in parallel spaced relation, the cable then providing a lead to the electrode array.

Figure 4 illustrates the variation of resistance with contact pressure at the point of application of the pressure for a sensor constructed as described above by way of example, using a cotton/wool mixture cloth approximately 0.3 mm thick, the application of carbon being carried out by soaking the cloth in 50 ccs of solvent loaded with 2.5 grams of carbon black.

In another particular form of the sensor described with reference to Figures 1, 2 and 3 the mat comprises a piece of cloth woven from a yarn consisting of aromatic polyamide fibres coated with a graphite loaded polymer material.

It will be appreciated that whilst in the sensors described above by way of example the mat is in the form of a cloth woven from yarn formed of filaments coated with electrically conductive material, this is not necessarily the case in a sensor according to the invention. Thus the mat may for example comprise filaments coated with electrically conductive material compacted into a matrix to form a felt-like material.

#### CLAIMS

1. A tactile sensor comprising a compressible mat of electrically resistive material and an array of electrodes on at least one main face of the mat wherein the electrically resistive material comprises filaments coated with electrically conductive material.

2. A sensor according to Claim 1 wherein the filaments are fibres of a natural material.

3. A sensor according to Claim 2 wherein the fibres are wool fibres.

4. A sensor according to Claim 2 wherein the fibres are a mixture of wool fibres and fibres of at least one other natural fibre.

5. A sensor according to Claim 4 wherein said other natural fibre is cotton.

6. A sensor according to any one of Claims 2 to 5 wherein said electrically conductive coating material comprises carbon particles.

7. A sensor according to Claim 6 wherein said

carbon particles are in the form of carbon black.

8. A sensor according to Claim 1 wherein the filaments are fibres of a synthetic material.

9. A sensor according to Claim 8 wherein the fibres are aromatic polyamide fibres.

10. A sensor according to Claim 8 or Claim 9 wherein said electrically conductive coating material comprises a graphite loaded polymer material.

11. A sensor according to any one of the preceding claims wherein the filaments are bonded together with an adhesive.

12. A sensor according to Claim 11 wherein the adhesive is a rubber-resin adhesive.

13. A sensor according to any one of the preceding claims wherein the mat is in the form of a cloth woven from yarn formed of the filaments.

14. A sensor according to any one of the preceding claims wherein the electrodes consist of metal foil.

15. A sensor according to any one of Claims 1 to 13 wherein the electrodes consist of silicone rubber loaded with metal.

16. A sensor according to any one of Claims 1 to 13 wherein the electrodes are formed by removing the insulation from end portions of the conductors of a multi-way cable and laying the stripped conductors out in parallel spaced relation, the cable then providing a lead to the electrode array.

17. A sensor according to any one of the preceding claims having an electrode array on each main face of the mat, each array comprising a series of parallel spaced apart conductors with the conductors of one array extending transversely to the conductors of the other array.

18. A sensor according to any one of the preceding claims wherein the mat and the or each electrode array is housed in a protective casing.

19. A sensor according to Claim 18 wherein the protective casing comprises two sheets of material, one on each side of the mat, which project beyond the edges of the mat with the space between the projecting parts of the sheet filled with a material to which the sheets are bonded.

20. A sensor according to Claim 19 wherein the electrodes of the or each electrode array are supported on the adjacent said sheet.

21. A tactile sensor substantially as hereinbefore described with reference to Figure 1 or Figure 3 of the accompanying drawings.